The Portable Crutch
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Abstract
Crutches are an essential tool in assisting with mobility of injured persons. The traditional crutch design imposes an obstacle when dealing with transportation; they are too large to fit in basic plane storage compartments, are a nuisance on a bus, and too long to fit into smaller sedans as shown in Fig. 1. Our modified design will cut the size of the crutches in half, eliminating the problem of transporting crutches that are too large.

Design Development
Initial design’s included a retractable tubing system, two hinge rotating system, and a two piece system that is held together with a locking mechanism.

Through research, our intended market deemed minimizing cost an important issue with the portable crutches. With this in mind the retractable tubing design was eliminated as well as the double hinge system due to cost and possibly compromising structural integrity.

The two piece system using a locking mechanism was then chosen as the primary design with the following features:

- Original crutch sawed in half to allow separation
- Locking collar mechanism similar to a bike seat holding the crutch together shown in Fig. 3.
- Inner tube that links both the top and bottom of the crutch
- Chord to hold the separated pieces together
- Velcro straps to secure the folded system together
- Pieces machined out of Aluminum-6061 for light weight, and low cost

Testing and Results
Comparisons of the benchmark and prototype are shown in Table 1. Our final prototype met the following initial design features:

- Effective Length reduced up to 50% (see Fig. 2)
- Able to support 150 lbs safely (tested with dumbbells)
- Only takes 10 seconds to fold/unfold
- Height range of 5’1-6’7 satisfies the height range for our intended market

Analysis and Conclusion
The strain and stress analysis of the collar depicted in Fig. 4, shows that the collar will elastically deform upon locking due to a 33.2 MPa stress, but will not reach its yield stress of 275MPa and plastically deform. The lock opens with 11.7 lbf (52.0 N) applied to the lever for ease of use. The crutch itself will successfully hold 185 lbs (84 kg) before plastically deforming, per Solidworks simulation, allowing a pair to support 370 lbs at its maximum. This gives a 70 lb cushion to allow safety for a crutch user of 300 lbs. In conclusion, the prototype successfully meets the requirements of our intended design features.

Acknowledgments & References
Steve Laguette, Daniel de Laveaga, Garret Smalley, John Clark
W.D. Callister, Jr. & D.G. Rethwisch,
Materials Science and Engineering An Introduction-8th edition

Table 1. Prototype and Benchmark feature comparison
<table>
<thead>
<tr>
<th>Aspect</th>
<th>Prototype</th>
<th>Benchmark</th>
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<tbody>
<tr>
<td>Length for 5’7” user (folded/unfolded)</td>
<td>2’4” / 4’3” (71.1 cm / 129.5cm)</td>
<td>NA / 4’3” (129.5 cm)</td>
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<tr>
<td>Weight</td>
<td>2.47 lbs (1.12 kg)</td>
<td>2.03 lbs (0.92 kg)</td>
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<td>Safe Load Support (per pair)</td>
<td>300lbs (136 kg)</td>
<td>300lbs (136 kg)</td>
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<td>Cost (Mass Production)</td>
<td>$55 (Estimate)</td>
<td>$40</td>
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<tr>
<td>Time to Fold/Unfold</td>
<td>10 seconds</td>
<td>N/A</td>
</tr>
<tr>
<td>User Height Range</td>
<td>5’1-6’7” (154.9-200.7cm)</td>
<td>4’7” – 6’7” (139.7-200.7cm)</td>
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Figure 1. Difficulty fitting benchmark crutches in a car
Figure 2. Benchmark (left) versus Prototype (middle, right)
Figure 3. Solidworks rendering of the folded crutch (left) and exploded view of locking mechanism (right)
Figure 4. Strain (left) and stress (right) analysis of collar